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# Detect and Avoid (DAA)
# White Paper

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## FOREWORD

This report was prepared by RTCA Special Committee 228 (SC-228) and approved by the RTCA Program Management Committee (PMC) on (date)

RTCA, Incorporated is a not-for-profit corporation formed to advance the art and science of aviation and aviation electronic systems for the benefit of the public. The organization functions as a Federal advisory committee, and develops consensus-based recommendations on contemporary aviation issues. RTCA's objectives include but are not limited to:

- coalescing aviation system user and provider technical requirements in a manner that helps government and industry meet their mutual objectives and responsibilities;

- analyzing and recommending solutions to the system technical issues that aviation faces as it continues to pursue increased safety, system capacity and efficiency;

- developing consensus on the application of pertinent technology to fulfill user and provider requirements, including development of minimum operational performance standards for electronic systems and equipment that support aviation; and

- assisting in developing the appropriate technical material upon which positions for the International Civil Aviation Organization and the International Telecommunication Union and other appropriate international organizations can be based.

The organization's recommendations are often used as the basis for government and private sector decisions as well as the foundation for many Federal Aviation Administration Technical Standard Orders and several advisory circulars.

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# 1. INTRODUCTION

This document contains the Plan and Description for development of Phase I Minimum Operational Performance Standards (MOPS) for Unmanned Aircraft System (UAS) Detect and Avoid (DAA) system. The standards will specify performance standards that should be useful to designers, manufacturers, installers and users of the equipment. Emphasis for this initial phase will be standards development on civil UAS equipped to operate into Class A or restricted airspace under IFR, and will not apply to sUAS operating under a different standard, if and when such standards becomes available.

Compliance with the to be-developed standards is recommended as one means of assuring that the equipment will perform its intended function(s) satisfactorily under all conditions normally encountered in routine aeronautical operation as described in the RTCA SC-228 Terms of Reference (TOR) and this document for DAA Phase I. Any regulatory application of this document is the sole responsibility of appropriate governmental agencies.

Sections of this document provide information needed to understand the rationale for development of equipment characteristics and work to be performed in the remaining sections. It describes typical operations and operational goals, as envisioned by the members of Special Committee SC-228, and establishes the basis for the standards that will be developed. Definitions and assumptions essential to proper understanding of this document are also provided.

The standards to be developed will specify the required DAA performance under standard environmental and operational conditions that will be defined as described in the Work Plan section later in this document. Also included in the MOPS will be recommended test procedures necessary to demonstrate equipment compliance with the minimum requirements.

The MOPS will describe the performance required of the DAA system hardware, software, firmware, processors, DAA displays & controls, and data links collectively referred to as DAA equipment in the remainder of this document. To the maximum extent possible, required data link performance will be included by reference to the Phase 1 C2 MOPS concurrently under development by the SC-228 C2 Working Group. Tests for the DAA installed equipment are to be included in the MOPS when performance cannot be adequately determined through bench testing.

The MOPS will describe the operational performance characteristics for DAA equipment installations and will define conditions that will assure the equipment user that operations can be conducted safely and reliably in the expected operational environment.

The MOPS will consider a DAA equipment configuration consisting of: sensors, processors, software/firmware, communication data links, and displays and controls that will allow the Pilot in Command (PIC) of an UAS to conduct safe and efficient transit operations through Class D, E and G airspace while not in the traffic pattern. Operational performance standards for functions or components that refer to equipment capabilities that exceed the stated minimum requirements will be identified as optional features. Performance requirements and associated test procedures may be developed for these optional features. Schedule and other resource constraints will limit the identification and specification of optional features.

The word “equipment” as used in this document includes all components and units necessary for the system to properly perform its intended function(s). For example, the “equipment” may

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include Active Surveillance and Automatic Dependent Surveillance – Broadcast (ADS-B) cooperative sensors, Electro-Optical and Radar non-cooperative sensors, computer processors, data links (e.g., Control and Non Payload Communication (CNPC) Radio), and pilot displays. In the case of this example, all of the foregoing components and units comprise the "equipment." It should not be inferred from this example that each DAA design will necessarily include all of the foregoing components or units or that this is a complete list of equipment for a satisfactorily operational system. This will depend on the specific design chosen by the manufacturer.

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## 2. BACKGROUND

The requirement to “see and avoid” other aircraft is part of the regulations governing the general operation of aircraft in the National Airspace System (NAS) under Title 14 Code of Federal Regulations (14CFR), Part 91, §91.111, §91.113(b), and §91.181(b). Although the requirements stated in the regulations are described as right-of-way rules, the intent of these regulations when taken together is to avoid collisions, remain well clear from other aircraft, and comply with right-of-way rules.

While these operating regulations are specific, the concept of well-clear is non-specific in nature and requires a pilot’s subjective assessment when performing maneuvers for this purpose. This is problematic for designing an engineering solution to meet the “see and avoid” requirement. To set performance requirements for an equipment standard, quantitative descriptions for well clear violation and Near Mid-Air Collision (NMAC) will be used.. Furthermore, thresholds that determine when action is needed to avoid these boundaries may be required to ensure interoperability and compatibility with other ATM functions. These thresholds may not necessarily be fixed boundaries in space, but may be dynamic and dependent on the "time" to closest point of approach (CPA), closure rate, maneuverability, and other factors. These thresholds may be different and dynamic for each aircraft being tracked in the vicinity of the UAS, dependent on the phase of flight, and may change over time as an encounter progresses. The NMAC volume is a well-established definition for Collision Avoidance at 500 foot horizontal and +/-100 feet vertical and will be used for the Phase I MOPS effort.

A system designed to provide the ability to self-separate (i.e., remain well clear of) from and avoid collisions with other aircraft is termed a DAA system. The DAA system notionally consists of a surveillance sensor (or suite of sensors), trackers and/or surveillance data fusion/correlation logic, threat detection and resolution logic, the display of traffic information and resolution guidance, and controls. The system and its architectural components must be designed to an appropriate level of system performance and design assurance to comply with the target level of safety.

The FAA’s UAS Operational Concept document includes assumptions, constraints, requirements, and high level operational considerations for UAS and are intended to provide the foundation for the Phase 1, DAA system MOPS. The narrow scope and functionality of this initial DAA MOPS may require specific restrictions, operating limitations and/or supplemental operational controls or provisions to achieve an acceptable level of collision risk mitigation for use in the NAS. Any such restrictions or operating limitations and/or supplemental operational controls or provisions will be provided as an output of the DAA working group efforts and documented as part of the MOPS provided to the FAA.

A work plan for SC-228 has been established to ensure that requirements and performance needs are documented and coordinated between Working Groups. The work plan is found later in this document.

This paper defines the assumptions, envisioned approach, bounds of the approach, the core requirements for, and the approach to defining further requirements for UAS DAA Equipment. This UAS DAA equipment will be used to support UAS integration into the NAS, specifically Phase I of these MOPS supports UAS transition to and from Class A or special use airspace. The

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following basic precepts taken from ICAO Annex 2, 19 Nov 2009 (Amendment 42) apply to the DAA Working Groups development of the Phase I MOPS:

- Avoidance of collisions: It is important that vigilance for the purpose of detecting potential collisions not be relaxed on board an aircraft, regardless of the type of flight or the class of airspace in which the aircraft is operating.
- Proximity: An aircraft shall not be operated in such proximity to other aircraft as to create a collision hazard.

The RTCA SC-228 Steering Committee provides senior stakeholder guidance and maintains configuration control of the RTCA SC-228 TOR which are approved by the RTCA Program Management Committee (PMC). Frequent consultation with the SC-228 Steering Committee while preparing the White Paper deliverables is anticipated. This White Paper is due to be delivered from the SC-228 to the RTCA Program Management Committee in December 2013.

This White Paper describes the DAA Working Groups plans for development, verification and validation of preliminary MOPS for UAS DAA Equipment in the specified Operational Environment. This White Paper includes recommendations for a Verification and Validation plan to be developed and then executed before the release of the DAA MOPS. The DAA draft MOPS are due from SC-228 to the PMC in July 2015.

Phase I will conclude with the delivery of the final Phase I DAA MOPS based on the results of the Verification and Validation (V&V) activities and are due from SC-228 to the PMC in July 2016. V&V activities are anticipated to be performed using prototype hardware, software, firmware, displays, controls, processors, data-links, sensors, and other such components or subsystems as may be necessary and are to be provided by members of the RTCA SC-228 DAA community.

The primary intent of deliverables from this effort is for FAA use in integrating UAS safely and efficiently into the NAS (or other civil airspace). Additionally, it is believed that it is FAA's intent to invoke these MOPS through TSOs and Advisory Circulars material.

Special Committee 228 will terminate its activity (both Phases I and II) when the PMC approves the committee's final document. Any change/extension of the committee's work program, and by extension the DAA working groups work program, requires prior PMC approval.

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## 3. SCOPE OF THIS RTCA ACTIVITY

The DAA Working Group will develop and validate UAS DAA equipment MOPS for civil UAS. Phase I focuses on transitioning through Class D, E, and G airspace. Phase II will focus on extended UAS operations in Class D, E, and G airspace.

The Phase I MOPS will address transit of UAS through Classes D, E and G airspace, to FL 180 (Class A) or special use airspace per the Terms of Reference. The DAA WG is not convinced that this statement changes the scope of work needed to be performed in order to write the DAA MOPS. The DAA WG will monitor the development activity. If there is a set of operations that can be excluded by use of the term "transit" that helps limit the scope of work, the DAA WG will define the term "transit" accordingly.

In developing the Phase I DAA MOPS, the DAA Working Group may consider, only if necessary to establish a satisfactory safety case for UAS operation, an allocation of DAA requirements between the Unmanned Aircraft (UA) and the associated control station.

### 3.1 What is addressed in the Phase I MOPS

The DAA Phase I MOPS will as a minimum define the minimum functional and performance requirements, test procedures, limitations, and installation considerations for UAS DAA equipment required to be used in an operational environment where the UAS is transitioning to and from Class A or special use airspace, traversing Class D and E, and Class G airspace.

The term "Collision Avoidance" within FAA rule context refers to the legally defined equipment mandated for air carriers. The term "collision avoidance function" will be used within the context of DAA to mean a feature of DAA equipment designed to prevent a collision when the self-separation function has failed to keep the UA well clear.

The two principal functions of DAA systems are the self-separation function (SS) and collision avoidance function. The self-separation function and collision avoidance function are to be included in scope of the Phase I MOPS. High level collision avoidance requirements will be documented but a Collision Avoidance algorithm, such as the one defined by RTCA DO-185, will not be developed within the Phase I or Phase II DAA MOPS. These high level collision avoidance function requirements will be captured distinctly and separately. SC-228 will draft an Inter-Special Committee Requirements Agreement (ISRA) with SC-147, Traffic Alert & Collision Avoidance System (TCAS) special committee, to develop performance and interoperability requirements for a UAS collision avoidance function compatible with Traffic Alert and Collision Avoidance System (TCAS) II and future Collision Avoidance systems (e.g., ACAS X) FAA plans to develop an ACAS $X_u$ algorithm, suitable for UAS collision avoidance, as a separate effort.

The Phase I DAA MOPS will address an airborne sense and avoid architecture. In this architecture, the UA will carry cooperative and non-cooperative sensors. The track information will be downlinked via the Command and Control (C2) data link to the UA control station. The PIC will use this information and associated guidance to remain well clear. In this architecture, the UA may contain an ability to automatically avoid collisions should there be an interruption in the C2 data link, or a failure to act by the PIC, or some other system condition that would require an automated response.

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